Instruction Handbook for

AIL Type 74

Automatic

NOISE-FIGURE INDICATOR

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AIRBORNE INSTRUMENTS LABORATORY
A DIVISION OF CUTLER-HAMMER, INC.
1345 NEW YORK AVE. HUNTINGTON STATION, N. Y.

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TABLE OF CONTENTS

		Page
Section I.	General Description	1
	1. Purpose and Applications	1
	2. Specifications	1
	3. Description of Equipment	2
Section II.	Theory of Operation	3
	1. General	3
	2. Noise Generators	4
	3. Y Factor	5
	4. Noise-Lamp Modulator	6
	5. Circuit Description	7
Section III.	Operation	11
	1. Interconnections	11
	2. Automatic Noise-Figure Measurement	11
	3. Manual Noise-Figure Measurement	12
	4. Checks and Adjustments	13
	5. Precautions	16
Section IV.	Maintenance Instructions	19
	1. Visual Inspection	19
	2. Power Supply	19
	3. Multivibrator and Modulator	19
	4. Automatic Gain Control (AGC)	20
	5. Video Amplifier and Synchronous Detector	20
	6. I-F Amplifier	21
	7. Meter Calibration	21
	8. Noise Generator	21
	9. Replaceable Parts	24
	10. Noise Diode	24

LIST OF ILLUSTRATIONS

Figure	
1	Y Factor vs Noise Figure for 15.28-db Noise Source
2	Automatic Noise-Figure Indicator, Functional Block Diagram
3	Type 74 Automatic Noise-Figure Indicator, Schematic Diagram
4	I-F Amplifier of Automatic Noise-Figure Indicator, Schematic Diagram
5	Typical Bench Setup Using Automatic Noise-Figure Indicator and Noise Generator for Automatic Noise-Figure Measurement
6	Bench Setup for Manual Noise-Figure Measurement
7	Noise Diode Current vs Noise Figure
8	Reduction in Excess Noise Power Output as a Function of Fired Insertion Loss
9	Noise Diode, Schematic Diagram

LIST OF TABLES

Table		Page
I	Arrangement of Switching System	9
II	I-F Amplifier Alignment	22
III	I-F Amplifier, D-C Voltage Chart	23
IV	Automatic Noise-Figure Indicator, D-C Voltage Chart	25
V	I-F Amplifier, Resistance Chart	26
VI	Automatic Noise-Figure Indicator, Resistance Chart	27
VII	Waveforms	28
VIII	List of Replaceable Parts	29
IX	Noise Tube Current and Replacement Data	38

SECTION I
GENERAL DESCRIPTION

1. PURPOSE AND APPLICATIONS

The AIL Type 74 Automatic Noise-Figure Indicator (ANFI) is intended primarily for the automatic monitoring of noise figures of receivers, tuners, and other equipment during actual operation. The effects of adjustments and modifications of the equipment under test can thus be immediately observed. The instrument is completely automatic and requires no auxiliary equipment or interpolations for operation.

Another important application of the ANFI is its use as a precision receiver for relative-gain measurements. With the addition of a calibrated i-f attenuator, quick measurements of power-level differences up to 65 db can be made.

2. SPECIFICATIONS

Noise-figure range	Low scale 0 to 25 db High scale 23 to 36 db, calibrated with extension to infinity
R-F range	12 Mc to 40 kmc
Accuracy	Low scale $\pm$0.5 db High scale $\pm$1 db
Input sensitivity (noise generator off)	50 μv into 50 ohms at 30 Mc* 100 μv into 50 ohms at 60 Mc
Dynamic range (AGC)	Greater than 65 db
Intermediate frequency	30 or 60 Mc standard

* The AGC circuits will regulate receiver gain down to a C-W input of 50 μv at the i-f center frequency. An equivalent amount of noise must be supplied to the i-f input of the ANFI to maintain its calibration.

Bandwidth	6.0 Mc minimum
Power output	Sufficient to operate all AIL noise sources in both automatic and manual modes
Meter function	Noise figure (two ranges), second-detector current, noise-tube current
I-F gain control	Available for manual operation
Recorder output for noise figure	0.05 volt dc across 10,000 ohms
AGC output	-2 to -6 volts dc
Input power	110 volts ac, 60 cps
Overall dimensions	19 inches wide by 8 3/4 inches high by 14 inches deep
Net weight	60 pounds
Shipping weight	75 pounds

3. DESCRIPTION OF EQUIPMENT

The complete equipment can be divided functionally into two main units: the noise source (consisting of the appropriate argon discharge lamp and/or noise diode, a low-frequency oscillator, and a square-wave modulator), and the noise-figure measuring equipment (consisting of a gain-controlled i-f amplifier, video detector, video amplifier, synchronous detector, and indicating meter). The noise generator is coupled to the receiver or other piece of equipment under test. The i-f output of the equipment under test feeds the i-f amplifier of the ANFI. The square-wave modulated noise signal in the ANFI is amplified in a gain-controlled i-f amplifier, detected, further amplified in video stages, detected in a synchronous detector, and fed into a differential cathode-follower meter circuit calibrated directly in decibels of noise figure.

SECTION II
THEORY OF OPERATION

1. GENERAL

The noise figure of a network is defined as the ratio of the available input-to-output signal-to-noise power ratios:

$$F = \frac{S_i/N_i}{S_o/N_o} \qquad (1)$$

where

F = the noise figure
S_i = the available signal input power
N_i = the available noise input power
S_o = the available signal output power
N_o = the available noise output power

Equation 1 implies that for an ideal (noiseless) network--where the signal-to-noise ratio is not degraded--$S_o/N_o = S_i/N_i$ and $F = 1$ (or 0-db noise figure). In actual cases, however, S_oN_o is small because of the noise generated in the network. Using a standard noise source, S_i/N_i is known. Furthermore, the noise output of a receiver of available gain G can be written as

$$N_o = G(N_i + N_r)$$

where N_r = the equivalent internally generated noise power referred to the input terminals

since

$$\frac{S_i}{S_o} = \frac{1}{G}$$

the noise-figure formula (equation 1) can be written as

$$F = \frac{1}{G} \times \frac{G(N_i + N_r)}{N_i} = 1 + \frac{N_r}{N_i} \qquad (2)$$

This is the basis for the noise-figure measurement system of the ANFI.

2. NOISE GENERATORS

a. GAS-DISCHARGE LAMP

Gas-discharge lamps are sources of noise power because of the random motions of the electrons when the gas is ionized. The term "noise temperature" is related to the mean electron velocity in the gas and is referred to 290 K.

Thus, the relative excess noise temperature of a gas-discharge lamp, referred to 290 K (T_o), can be written as

$$t_d - 1 = \frac{T_d - T_o}{T_o} = \frac{T_d}{T_o} - 1 \qquad (3)$$

where

T_o = the reference temperature, assumed to be 290 K
T_d = the discharge or ionized temperature

For a pure argon-discharge lamp, in which T_d is 10,100 K,

$$t_d - 1 = \frac{10,100}{290} - 1 = 33.8$$

The available relative excess noise power in decibels is therefore 10 log 33.8, or 15.28 db above thermal noise.

b. NOISE DIODE GENERATOR

The noise diode head uses a temperature-limited diode. It has a useful frequency range from 250 to 350 Mc.

The diode, a Sylvania type 5722, is a tungsten filament tube designed for use as a noise generator in frequencies up to about 400 Mc. The determining factors for the frequency range of this tube are the mountings used, transit time loading, and internal resonance. Since the tube has a tungsten filament, the shot noise is a known function of the d-c plate current if sufficient plate voltage is applied to obtain saturation. The excess noise generated is calculated by the equation

$$Fdb = 10 \log 20IR$$

where R is the generator termination in ohms, and I is the diode plate current in amperes.

For use with the Type 74 Automatic Noise-Figure Indicator, the excess noise from the generator is set at 15.3 db, the same as that obtained from the gas-discharge generators. A single meter calibration, therefore, can be used for all generators. This amount of noise, which is 15.3 db above thermal noise, is obtained by using 33.8 milliamperes of noise current when the noise diode generator is terminated in 50 ohms. The ANFI has provisions for a scale expansion when using the noise diode. Two ranges of noise current (0-5 ma and 0-50 ma) are available by making the proper switch selection.

3. Y FACTOR

In determining the noise figure of a network or system, it is neither easy nor convenient to measure the generated noise directly. A practicable indirect method

is to make two power-output measurements for two different input conditions. The ratio of these two outputs, called the Y factor, is related to the noise figure as follows:

$$F = \frac{\left(\frac{T_d}{T_o} - 1\right)\left(\frac{B_o}{B} - Y\right)\left(\frac{T_1}{T_o} - 1\right) - \left(\frac{B_o}{B} - 1\right)\left(\frac{T_i}{T_o} - 1\right)}{Y-1} \qquad (5)$$

where

B_o = the overall noise bandwidth (including image, spurious, and other responses)

B = the useful-channel bandwidth

T_i = the temperature of the termination in the noise-off condition

Y = the ratio of power output with the generator on to the output with the generator off (equation 1)

Usually, T_i is about the same as T_o; if B_o equals B, equation 5 reduces to

$$F = \frac{T_d}{T_o} - \frac{1}{Y - 1} \text{ (in power ratio)} \qquad (6)$$

or

$$F_{db} = 10 \log\left(\frac{T_d}{T_o} - 1\right) - 10 \log(Y - 1) \qquad (7)$$

When extreme accuracy is desired, equation 5 must be used to take account of temperature variation, image response, etc. Figure 1 shows the values of F_{db} in terms of Y (from equation 7).

4. NOISE-LAMP MODULATOR

In an automatic noise-figure indicating system, a means must be provided to periodically shut off the noise generator. This is accomplished in the ANFI by the square-

wave modulator. A 400-cps variable-frequency square-wave generator keys the noise lamp on and off. The output of the video detector consists of a square wave (as shown in Figure 2) whose maximum level corresponds to power output with the noise generator on, and whose minimum level corresponds to receiver noise alone (noise generator off). The peak-to-peak value of this square wave is therefore an indication of the noise figure of the network under test.

5. CIRCUIT DESCRIPTION

a. GAS-DISCHARGE LAMP

Figure 2 is a functional block diagram and Figures 3 and 4 are schematic diagrams of the ANFI. A 400-cps multivibrator and its associated amplifier produce both positive and negative pulses for simultaneous triggering of shunt modulator V8, which ignites the gas tube, and series modulator V10, which opens or closes the noise-lamp circuit.

When the negative-going pulse is applied to the grid of V8, the tube cuts off. As a result of the high inductance in the plate circuit, an instantaneous potential of from 1800 to 2200 volts is developed, which is sufficient to ionize the argon lamp. With the triggering of the shunt tube, the positive-going pulse from the amplifier drives series modulator V10 into conduction. Tube V10 is a dual triode (type 6AS7GA) with both sections in parallel to ensure adequate current for the noise lamp. At the end of the negative-going pulse, V10 cuts off, thereby breaking the noise-lamp circuit. The noise output then decreases to zero, and V8 again conducts.

b. NOISE DIODE

The noise diode uses a Sylvania 5722. A 6AS7GA (V10) is used in the 74 as the modulator control tube for the noise diode. Series plate modulation of the noise diode is obtained by using square-wave modulating voltages from the plates of V6 and V7 (the multivibrator and multi-amplifier, respectively) on the grid of V10. The noise diode, which is

in the cathode circuit of V10, is driven in and out of conduction from cutoff into saturation. Switching is required to operate the noise diode in the ANFI and manual modes. Two current noise ranges are provided for the diode (0-5 ma and 0-50 ma).

c. I-F AND VIDEO AMPLIFIERS

The i-f and video amplifiers are conventional circuits. The i-f amplifier is stagger-tuned and has a pass band of 6 Mc. The i-f gain of the peak-to-peak signal is automatically maintained constant by the AGC loop from the video detector to the first three stages. This enables calibration of the detector current for a gain check.

d. SWITCHING

The pushbutton switching arrangement of the ANFI has two dependent interlocked sets of buttons. The first set of buttons--MANUAL ON, MANUAL OFF, and AUTO NF ON--selects the mode of operation of the noise generator. The second set of buttons--NOISE GEN CURRENT, 2ND DET CURRENT, and NF RANGE HIGH and LOW--selects the indication presented on the meter.* Table I lists the possible circuit and function arrangements for various button settings; however, the information given in Table I is not intended as an operating procedure.

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* An additional rotary switch is provided to switch from the gas-discharge lamp to either range of the temperature-limited noise diode. The 0-5 ma range of noise diode current is used on manual Y-factor measurements only.

TABLE I

ARRANGEMENT OF SWITCHING SYSTEM

Initial Adjustments	Noise Generator Pushbuttons Pressed	Meter Indication Pushbuttons Pressed	Adjustment
Multivibrator duty cycle and frequency	None	None	R50 for duty cycle and pps
Manual noise generator current	MANUAL ON	NOISE GEN CURRENT	R63 for appropriate current in each tube
Automatic noise generator current	AUTO NF ON	NOISE GEN CURRENT	R49 for one-half of above
AGC level	AUTO NF ON	2ND DET	R13 for 0.5 ma
~~Zero~~ See Page 16	OFF	NF RANGE LOW	~~R40 for zero~~
High automatic noise figure	AUTO NF ON	NF RANGE HIGH	R30 for calibration
Low automatic noise figure	AUTO NF ON	NF RANGE LOW	R31 for calibration

SECTION III
OPERATION

1. INTERCONNECTIONS

Four simple steps are followed in setting up the ANFI for an automatic noise-figure measurement (Figure 5).

a. Connect the ANFI to a 115-volt 60 cps power source (a minimum warm-up time of 15 minutes is recommended).

b. Connect the high- and low-voltage cables to the argon discharge noise generator, or plug in the noise diode head. Switch to the appropriate gas or diode generator.

c. Connect the output of the noise generator to the input of the receiver or other equipment to be tested (this includes proper termination of the noise generator).

d. Connect the i-f output of the equipment under test to the i-f input of the ANFI.

2. AUTOMATIC NOISE-FIGURE MEASUREMENT

Automatic measurement of noise figure is made in the following manner, using the NOISE GENERATOR and METER INDICATION pushbuttons.

a. With the POWER switch in the ON position, allow the instrument to warm up for about 15 minutes.

b. Press the NOISE GENERATOR AUTO NF ON and the METER INDICATION 2ND DET CURRENT pushbuttons. Select either the gas or diode noise generator. The meter then reads the rectified second-detector current at the output of the i-f amplifier. The meter should read 0.5 ma, indicating proper AGC action. (The AGC circuits will regulate receiver gain down to a C-W input of 50 μv at an intermediate frequency of 30 Mc.) An equivalent amount of noise must be applied to the i-f input of the ANFI to maintain its calibration.

c. Press the NOISE GENERATOR AUTO NF ON and METER INDICATION NF RANGE HIGH or LOW pushbuttons, and read the noise figure on the meter.

3. MANUAL NOISE-FIGURE MEASUREMENT

When a continuous monitoring of the noise figure of an instrument is not desirable (or when a single measurement of greater accuracy is desired), the ANFI can be used in conjunction with a calibrated i-f precision attenuator for manual noise-figure measurements. Figure 6 shows the bench setup for such a measurement. A manual measurement of noise figure is made in the following manner.

a. ARGON-DISCHARGE NOISE GENERATOR

1. Interconnect the equipment as shown in Figure 6, and allow about 15 minutes for warm up.
2. Rotate the noise generator switch to the GAS position.
3. Press the METER INDICATION 2ND DET CURRENT and NOISE GENERATOR MANUAL OFF pushbuttons.
4. Adjust the MANUAL GAIN control for a convenient indication on the meter. If the equipment under test has a variable-gain preamplifier, it is desirable to set it at or near its maximum gain. Observe the reading on the meter.
5. Note the i-f attenuator reading in db.
6. Press the NOISE GENERATOR MANUAL ON pushbutton. This action will inject the noise voltage into the system, and increase the meter deflection (an off-scale reading may result). Do not change the setting of the MANUAL GAIN control.
7. Increase the i-f attenuation until the meter reading returns to the originally observed (no-noise) value. The difference between the attenuator settings in steps 5 and 7 is the Y factor.
8. Using the Y-factor curve (Figure 1), obtain the actual noise figure of the equipment under test.

b. DIODE NOISE GENERATOR

1. Interconnect the equipment as shown in Figure 6 and allow about 15 minutes for warm up. The 3-db method is utilized (a Y factor of 2) when using the noise diode.

2. Rotate the NOISE GENERATOR SWITCH to the DIODE position.

3. Press the NOISE GENERATOR MANUAL OFF and the METER INDICATION 2ND DET CURRENT pushbuttons. Rotate the DIODE CURRENT ADJUST control fully counter-clockwise.

4. Adjust the IF GAIN control for a convenient indication on the current scale. Set the PRE-AMP GAIN control at or near maximum. Observe and note the reading on the meter.

5. Note the i-f attenuator reading in db.

6. Increase the attenuator setting by 3 db, and press the NOISE GENERATOR MANUAL ON pushbutton.

7. Rotate the DIODE CURRENT ADJUST control in a clockwise direction until the indication on the CURRENT scale of the meter is the same as that observed in step 4.

8. Read the noise diode current on the meter.* The noise figure in db can now be obtained from the current-noise figure curve provided in Figure 7.

4. CHECKS AND ADJUSTMENTS

Both the automatic and the manual methods of noise-figure measurement with the noise generator and the ANFI are based upon predetermined and preset operating characteristics of these equipments. It is therefore desirable to make the following checks and adjustments of these characteristics at periodic intervals.

a. MULTIVIBRATOR ADJUSTMENT

Potentiometer R50 independently controls the frequency of operation and duty cycle of the multivibrator. Varying potentiometer R50 will change the frequency of oper-

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* Low noise figures can better be read by using the 0-5 ma range on the Noise Generator "Gas-Diode" switch.

ation and the duty cycle. To change the frequency of operation and retain a 50-percent duty cycle, potentiometer R50 must be adjusted by observing the multivibrator waveform at test point 5.

The duty-cycle adjustment is made only once when initially checking out the instrument.

b. MODULATOR TRIGGER ADJUSTMENT

Potentiometer R57 is adjusted to sustain automatic operation of the gas noise generator. When properly adjusted, the leading edge of the current pulse (as viewed at test point 8) will have a slight overshoot. This overshoot not only ensures proper firing of the gas noise generator but also provides a quenching impulse that aids in the deionization.

c. NOISE-GENERATOR CURRENT

(1) Manual

The gas lamps used in the noise generator are calibrated for various nominal currents listed in Table IX. For each lamp a $\pm$10 percent deviation from the calibrated current will not effect the noise output by more than 0.1 db. For precise measurements, however, it is desirable to set this current to the exact nominal current for each lamp. To obtain an indication of gas-lamp current, press the NOISE GENERATOR MANUAL ON and METER INDICATION NOISE GEN CURRENT pushbuttons. Lamp current can be adjusted by turning potentiometer R63, located on the rear of the chassis. An additional noise current setting can be obtained by using the slide wire resistor under the chassis.

(2) Automatic

Press the NOISE GENERATOR AUTO NF ON pushbutton, and adjust potentiometer R49 (located on the modulator board) for half the reading obtained when in manual operation. In automatic operation, the gas-lamp current is one-half the

peak current through the gas lamp, because of the modulated mode of operation. The noise diode current in automatic operation may not always be half of that obtained in manual operation.

d. AGC LEVEL ADJUSTMENT

Since the meter calibration is based upon a constant voltage level output from the i-f amplifier, AGC is provided. To obtain AGC, press the NOISE GENERATOR AUTO NF ON and METER INDICATION 2ND DET CURRENT pushbuttons, and adjust R13 for 0.5 ma.

e. METER CALIBRATION

Meter calibration potentiometers R30 and R31 correct variations in video-amplifier gain and variations due to aging, tube-component replacement, etc. This adjustment may have to be made periodically, depending upon the conditions under which the equipment is used. When the noise figure of the system under test has been determined by the manual Y-factor method, potentiometer R31 is adjusted in automatic operation to indicate the noise figure directly on the meter. The high noise-figure range is calibrated by inserting an accurate attenuator between the noise generator and the system under test. Potentiometer R30 is then adjusted for a meter indication of the original noise figure plus the attenuator loss.

f. DETECTOR CURRENT WITH AGC OFF

When manual noise-figure measurements are made, the AGC is removed by pressing the NOISE GENERATOR MANUAL ON or OFF pushbutton. The i-f gain is then adjusted manually, and the reference reading is noted on the 0 to 0.5 ma scale when the METER INDICATION 2ND DET CURRENT pushbutton is pressed.

g. MANUAL GAIN

This adjustment is effective only when the NOISE GENERATOR MANUAL ON or OFF pushbutton is pressed and is used

for the manual noise-figure measurement. The i-f gain is adjusted for a convenient reading on the meter scale, depending upon the gain of the equipment being tested.

h. ZERO ADJUSTMENT

Press the NOISE GENERATOR AUTO NF ON and METER INDICATION LOW NF RANGE pushbuttons, and disconnect the i-f input. Turn ZERO ADJ potentiometer R40 until the meter reads ∞.

5. PRECAUTIONS

In making noise-figure measurements, observe the following precautions to avoid measurements inaccuracies.

a. BANDWIDTH EFFECTS

In making a noise-figure measurement, the overall noise bandwidth (including image, spurious, and other responses) determines the actual noise figure of the equipment under test. Thus, the harmonic and spurious r-f responses may make the actual indicated noise figure better than the actual value. For example, assuming the image response to be equal to the useful-signal response, the indicated noise figure. To obtain the true noise figure of the equipment under test, the effect of spurious image responses must be accounted for properly (see equation 2).

b. GENERATOR TEMPERATURE

The noise-figure measurement outlined in paragraph 3 assumed that the argon gas-discharge generator temperature equals the temperature of the discharge. This is true if there is complete coupling of the noise output to the equipment under test. Any lesser coupling causes a reduction in the noise fed to the equipment under test. A measure of this coupling is the insertion loss of the fired generator. Using Figure 8, a correction to the final noise figure obtained can then be made.

c. NOISE-SOURCE TERMINATION

The accuracy of any noise-figure measurement depends upon the proper termination of the noise generator. The noise generator should be terminated with a 50-ohm load. The noise diode requires no termination.

d. TERMINATION TEMPERATURE

The effect of temperature variation of the noise-generator termination has little significance, except when making low noise-figure measurements of maximum accuracy. If the termination temperature (normally assumed to be about 290 K) changes appreciably because of prolonged use or other factors, a correction of the noise figure must be made.

e. Y-FACTOR MEASUREMENT

The Y-factor measurement should be made quickly to eliminate errors due to changes of the open loop gain of the receiver (no AGC).

SECTION IV
MAINTENANCE INSTRUCTIONS

1. VISUAL INSPECTION

A thorough visual inspection should be made on all components in the ANFI. This includes checking capacitors, chokes and transformers for leakage, and corrosion around contact points. Since the ANFI utilizes printed-circuit boards, an inspection system is required. A simple inspection method is to place a light behind the printed-circuit boards to make them transparent.

The visual inspection should also include inspection of the modulator cables. The cables should be tight in their receptacles and the receptacles themselves checked for any loose components. In addition, the visual inspection should include a check of all the tubes in the ANFI.

2. POWER SUPPLY

Power-supply output voltages can be checked on the modulator printed-circuit board by measuring the voltages between test points 1, 2, and 3, and ground. The measured voltages between test point 1 and ground is +350 volts dc unregulated. Test point 2 should yield +150 volts dc regulated, test point 3 should yield -150 volts dc regulated. Potentiometer R8 (located on the modulator printed-circuit board) is an adjustment for the +150 volt regulated supply. During maintenance, R8 should be adjusted to give +150 volts at test point 2.

3. MULTIVIBRATOR AND MODULATOR

The multivibrator operates at a nominal frequency of 400 cps (variable from 380 to 420 cps). Potentiometer R50, located on the modulator printed-circuit board, adjusts both the frequency and the duty cycle of the multivibrator. Test point 5 can be used to observe the waveforms on the plate of the multivibrator, and test point 6 can be used to observe

the grid waveforms. The output of the multivibrator is fed into a squaring amplifier that drives the high-voltage modulator. The modulator section contains three separate adjustments, which have the following functions.

a. NOISE-TUBE CURRENT ADJUSTMENT

Potentiometer R63 adjusts the noise-generator current when the NOISE GENERATOR MANUAL ON pushbutton is pressed.

b. AUTO-CURRENT ADJUSTMENT

Potentiometer R49 varies the noise-generator current while the ANFI is operating in the automatic mode. It adjusts this current to one-half the C-W noise-generator current (when using the gas-discharge generators).

c. MODULATOR TRIGGER ADJUSTMENT

Potentiometer R57 adjusts the modulator so that it will ensure firing of the noise generator each time the NOISE GENERATOR AUTO ON pushbutton is pressed.

CAUTION

Extreme care should be used when testing the modulator section. Voltages of 2500 volts are present at the plate of V8 (6AU5). No attempt should be made to measure this voltage unless proper precautions and adequate test equipment are used.

4. AUTOMATIC GAIN CONTROL (AGC)

AGC is provided to maintain a constant voltage level output from the i-f amplifier. AGC level adjust potentiometer R13 is adjusted for a second-detector current of 0.5 ma, with an i-f input level of 100 μv. This current should remain within ±5 percent over a 65-db i-f input range.

5. VIDEO AMPLIFIER AND SYNCHRONOUS DETECTOR

Video amplifier V5 feeds a synchronous detector that obtains its synchronizing voltage from the cathode-

follower output of amplifier V7. The presence of a video signal can be checked at test point 4. When the METER INDICATION NF RANGE HIGH or LOW pushbutton is activated from the high to low noise-figure ranges, a change of about 17:1 in the video signal level should occur. The synchronizing voltage required to operate the detector circuit can be observed at test point 9. The detector output can be observed at test point 11.

6. I-F AMPLIFIER

The maintenance of the i-f amplifier is dependent upon the alignment and adjustment of the coils, as listed in Table II. To prevent AGC action during alignment, the NOISE GENERATOR OFF pushbutton should be pressed and i-f gain control R20 should be advanced to indicate -2.75 volts dc at the AGC test point. Table III lists the operating voltages for the i-f amplifier when the NOISE GENERATOR MANUAL OFF pushbutton is pressed.

7. METER CALIBRATION

The meter-calibration controls are located on the front panel: R30 for the 23 to 36 db range and R31 for the 0 to 25 db range. As tubes are replaced and other components in the ANFI change because of aging, recalibration of the meter circuit will be required. As noted in Section III, a Y-factor measurement should be made on both ranges. When an accurate measurement using the Y-factor method has been made, the unit is placed in automatic operation and meter-calibrating potentiometers R30 and R31 are adjusted according to the Y-factor noise-figure measurement.

8. NOISE GENERATOR

The noise generator should be checked at the contact ends for the corrosion, arcing, and poor contact between the noise-generator adapter connection and the noise-generator cables. Poor contact connections to the

TABLE II

I-F AMPLIFIER ALIGNMENT

Coil No.	Frequency (Mc)
L1	30.0
L2	33.7
L3	26.0
L4	29.0
L5	33.7
L6	26.0
L7	29.0

TABLE III

I-F AMPLIFIER, D-C VOLTAGE CHART

All readings taken with a vacuum-tube voltmeter and given in volts, referenced to ground.

All readings taken with the i-f input terminated in a 50-ohm load.

MANUAL GAIN control set to -2 volts at test point 10 with respect to ground.

Tube	Tube Type	Pin 1	2	3	4	5	6	7
V1		-2*	0.15	0	0	150	150	0.15
V2	6CB6	-2*	0.24	0	0	140	150	0.24
V3	6CB6	-2*	0.1	0	0	140	150	0.1
V4	6CB6	0	2.2	0	0	110	150	2.2
V5	6CB6	0	2.0	0	0	108	150	2.0
V6	6AN5	0	10.4	0	0	150	150	10.4

* Measured with tube out of circuit.

noise generator may result in poor ignition and transients from the noise generator. If the noise-generator tube becomes defective, replace it with the appropriate standard noise lamp as indicated in Table IX.

Tables IV through VI list voltage and resistance data, and Table VII shows the waveforms that should be observed.

9. REPLACEABLE PARTS

Table VIII is a list of replaceable parts.

10. NOISE DIODE

Figure 9 is the schematic diagram of the noise diode. Since the component arrangement is extremely critical, no attempt should be made to perform maintenance on the diode mount without adhering strictly to the physical layout of the components.

TABLE IV

AUTOMATIC NOISE-FIGURE INDICATOR,
D-C VOLTAGE CHART

All readings taken with a vacuum-tube voltmeter and given in volts, referenced to ground.

All readings taken with NOISE GENERATOR AUTO NF ON pushbutton pressed.

Tube	Tube Type	Pin 1	2	3	4	5	6	7	8	9
V1	6W6GT		0	285	285	140	0	0	150	
V2	6AU6	-3.4	0	0	0	140	150	0	0	
V3	0A2	0	-150	-150	-150	0		-150		
V4	12AX7	90	-3.8	-2.8	0	0	150	0	-2.8	0
V5	12AU7	110	0	3.6	0	0	110	0	3.6	0
V6	12AT7	100	-21	0	0	0	90	-24	0	0
V7	12AT7	215	-35	4	0	0	150	-36	0	0
V8	6AU5GT	-2	0	8	0	200	0	0	150	
V9	6AU4GTA			270		255				
V10	6AS7GA	-138	180	0.5	-138	180	0.5	0	0	
V11	12AT7	150	-0.6	-0.80	0	0	150	0	1	0

TABLE V

I-F AMPLIFIER, RESISTANCE CHART

All readings given in ohms with respect to ground.
POWER toggle switch in OFF position.

Tube	Tube Type	Pin 1	2	3	4	5	6	7
V1	6CB6		47	0	0			47
V2	6CB6		47	0	0			47
V3	6CB6		47	0	0			47
V4	6CB6	0	180	0	0			180
V5	6CB6	0	180	0	0			180
V6	6AN5	0	360	0	0			360

TABLE VI

AUTOMATIC NOISE-FIGURE INDICATOR,
RESISTANCE CHART

All readings given in ohms with respect to ground.

All readings taken with NOISE GENERATOR AUTO NF ON pushbutton pressed. (Note: This is the only pushbutton pressed during resistance readings of the ANFI.)

POWER toggle switch in OFF position.

Tube	Tube Type	Pin 1	2	3	4	5	6	7	8	9
V1	6W6GT		0					0	190 k	
V2	6AU6	110 k	0	0	0		190 k	0		
V3	0A2	0	7 k	7 k	7 k	0		7 k		
V4	12AX7	300 k	1.4 k	115 k	0	0	190 k	110 k	115 k	0
V5	12AU7	230 k	100 k	1 k	0	0	200 k	18 k	1 k	0
V6	12AT7	200 k	2 meg	0	0	0	200 k	2 meg	0	0
V7	12AT7	510 k	1.1 meg	3 k	0	0	190 k	1.1 meg	10	0
V8	6AU5GT	300 k	0	100				0		
V9	6AU4GTA									
V10	6AS7GA	1 meg	∞	10	1 meg	∞	10	0	0	
V11	12AT7	190 k	10 k	32 k	0	0	190 k	0	30 k	0

TABLE VII

WAVEFORMS

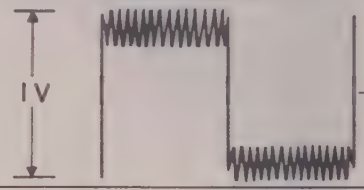
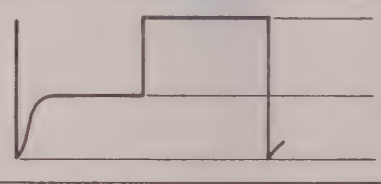
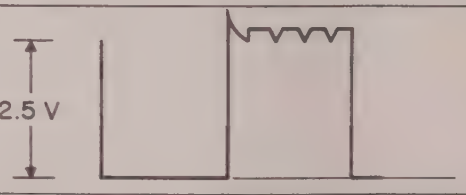
TEST POINT	D-C VOLTAGE	WAVEFORM
TP1	350	NOT APPLICABLE
TP2	150	NOT APPLICABLE
TP3	-150	NOT APPLICABLE
TP4	-0.2	 FREQUENCY = 400 CPS
TP5	117	 FREQUENCY = 400 CPS
TP6	-17	FREQUENCY = 400 CPS
TP7		FREQUENCY = 400 CPS
TP8	1.3	
TP9	0	
TP10	-3.2	NOT APPLICABLE
TP11	-0.6	NOT APPLICABLE

TABLE VIII

LIST OF REPLACEABLE PARTS

I-F AMPLIFIER

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
C1	Capacitor, 715 μμf	Type 331 HIK	Erie
C2	Capacitor, 20 μμf	N750K	Erie
C3	Capacitor, 1000 μμf	SB2A-102	Allen-Bradley
C4	Capacitor, 1500 μμf	DM-19-152	El Menco
C5 through C10	Same as C1		
C11	Capacitor, 51 μμf	N750K	Erie
C12 through C35	Same as C3		
CR1	Crystal diode	1N67	Raytheon or equivalent
L1	Inductor	112238	AIL
L2	Inductor	112239	AIL
L3	Inductor	112240	AIL
L4	Inductor	113333	AIL
L5	Same as L2		
L6	Same as L4		
L7	Same as L3		
L8	Inductor, 14 μh	Yellow dot	Jeffers
L9 through L14	Same as L8		
L15	Inductor 0.25 μh	Red dot	Jeffers
L16 through L20	Same as L15		

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
R1	Resistor, composition, 51 ohms ±5%, 1/2 w		Allen-Bradley
R2	Resistor, composition, 5100 ohms ±5%, 1/2 w		Allen-Bradley
R3	Same as R2		
R4	Resistor, composition, 2400 ohms ±5%, 1/2 w		Allen-Bradley
R5	Same as R2		
R6	Same as R2		
R7	Resistor, composition, 2700 ohms ±5%, 1/2 w		Allen-Bradley
R8	Resistor, composition, 6800 ohms ±5%, 1/2 w		Allen-Bradley
R9	Resistor, composition, 47 ohms ±5%, 1/2 w		Allen-Bradley
R10	Same as R9		
R11	Same as R9		
R12	Resistor, composition, 180 ohms ±5%, 1/2 w		Allen-Bradley
R13	Same as R12		
R14	Resistor, composition, 360 ohms ±5%, 1/2 w		Allen-Bradley
R15 through R19	Same as R12		
V1	Tube, electron	6CB6	RCA or equivalent
V2 through V5	Same as V1		
V6	Tube, electron	6AN5	RCA or equivalent

AUTOMATIC NOISE-FIGURE INDICATOR

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
C1	Capacitor, electrolytic, ~~40-20-8-8~~ 40-40-8-8 µf, ~~475~~ 500 vdc	TVL 4944	Sprague
C2	Capacitor, electrolytic, 40 µf, 450 vdc	TVL 1725	Sprague
C3	Capacitor, 0.5 µf, 200 vdc	BP-2-5	Astron
C4	Capacitor, 0.1 µf, 200 vdc	BP-2-1	Astron
C5	Same as C4		
C6	Capacitor, electrolytic, 2 µf, 50 v	SRE	Aerovox
C7	Same as C4		
C8	Same as C4		
C9	Capacitor, 51 µµf, 500 vdc	DM-15-S10	El Menco
C10	Capacitor, electrolytic, 4 µf, 150 v	TVA 1402	Sprague
C11	Capacitor, electrolytic, 50 µf, 25 v	BBR 50-25	Cornell-Dubilier
C12	Capacitor, 0.05 µf; 200 vdc	2TM-S5	Sprague
C13	Capacitor, electrolytic, 16 µf, 450 vdc	TVA 1708	Sprague
C14	Capacitor, 0.05 µf, 600 vdc	BP-6-0	Astron
C15	Capacitor, 0.002 µf, 200 vdc	6TM-D	Sprague
C16	Same as C15		
C17	Same as C4		
C18	Capacitor, mica, 2500 µµf, 3 kv	DD30252	Centralab

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
C19	Capacitor, 2 µf, 50 v	SRE	Aerovox
C20	Capacitor, electrolytic, 40 µf, 150 vdc	TVA 1413	Sprague
C21	Same as C19		
C22	Capacitor, 0.05 µf, 600 vdc	6TM-S5	Sprague
CR1	Crystal diode	1N96	Hughes
CR2 through CR4	Same as CR1		
CR5	Silicon diode	1N208	Hoffman
CR6	Silicon rectifier	1N2070	Texas Instruments
CR7 through CR12	Same as CR6		
F1	Fuse, 3 amp	AGC-6a	Buss
F2	Same as F1		
J1	Connector	126-222	Amphenol
J2	Not used		
J3	Connector, diode	165-36	Amphenol
L1	Inductor	C2991	Merrit
M1	Meter	#1751	Weston
R1	Resistor, wire-wound, 250 ohms, 25 w	0201	Ohmite
R2	Resistor, composition, 300 k ±5%, 1 w		Allen-Bradley
R3	Resistor, wire-wound, 500 ohms, 10 w	1-3/4 D-48-F	Ohmite
R4	Resistor, composition, 100 k ±5%, 1/2 w		Allen-Bradley

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
R5	Resistor, composition, 47 ohms ±5%, 1 w		Allen-Bradley
R6	Resistor, composition, 100 ohms ±5%, 1/2 w		Allen-Bradley
R7	Same as R4		
R8	Resistor, variable, 25 k ±30%, 1/2 w	LH 61	Stackpole
R9	Same as R4		
R10	Resistor, wire-wound 2 k, 10 w	1-3/4 D-48-F	Ohmite
R11	Same as R10		
R12	Resistor, composition, 1.2 k ±5%, 1/2 w		Allen-Bradley
R13	Resister, variable, 1 k ±30%, 1/2 w	LH61	Stackpole
R14	Resistor, composition, 150 k ±5%, 1/2 w		Allen-Bradley
R15	Resistor, composition, 62 k ±5%, 1/2 w		Allen-Bradley
R16	Same as R4		
R17	Resistor, composition, 620 k ±5%, 1/2 w		Allen-Bradley
R18	Same as R42		
R19	Resistor, composition, 3.9 k ±5%, 1/2 w		Allen-Bradley
R20	Resistor, variable, 5 k, 2 w	AB CU5021	Ohmite
R21	Resistor, composition, 300 k ±5%, 1/2 w		Allen-Bradley
R22	Resistor, composition, 56 k ±5%, 1/2 w		Allen-Bradley
R23	Resistor, composition, 2700 ohms ±5%, 1/2 w		Allen-Bradley

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
R24	Same as R14		
R25	Same as R4		
R26	Resistor, composition, 10 k ±5%, 1 w		Allen-Bradley
R27	Resistor, composition, 1 k ±5%, 1/2 w		Allen-Bradley
R28	Same as R27		
R29	Same as R42		
R30	Reiistor, variable, 5 k, 2 w	AB CLU5021	Ohmite
R31	Same as R30		
R32	Same as R26		
R33	Same as R27		
R34	Same as R6		
R35	Resistor, 3.9 k ±1%, 1/2 w	DCSH 1/2	Dalohm
R36	Same as R35		
R37	Same as R35		
R38	Same as R35		
R39	Same as R 2		
R40	Resistor, variable, 1 k, 2 w	AB CLU1021	Ohmite
R41	Resistor, composition, 36 k ±5%, 1 w		Allen-Bradley
R42	Resistor, composition, 1 meg ±5%, 1/2 w		Allen-Bradley
R43	Resistor, composition, 22 k ±5%, 2 w		Allen-Bradley
R44	Resistor, composition, 100 k ±5%, 1 w		Allen-Bradley
R45	Resistor, composition, 3 k ±5%, 1/2 w		Allen-Bradley

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
R46	Same as R4		
R47	Same as R42		
R48	Same as R41		
R49	Resistor, variable, 100 k ±30%, 1/2 w	LH61	Stackpole
R50	Resistor, variable, 1 meg ±30%, 1/2 w	LH61	Stackpole
R51	Resistor, composition, 1.3 meg ±5%, 1/2 w		Allen-Bradley
R52	Resistor, composition, 24 k ±5%, 1/2 w		Allen-Bradley
R53	Same as R52		
R54	Resistor, wire-wound, 5 k, 20 w	1 3/4-D-48-F	Ohmite
R55	Resistor, composition, 1.8 meg ±5%, 1/2 w		Allen-Bradley
R56	Resistor, composition, 10 k ±5%, 1/2 w		Allen-Bradley
R57	Resistor, variable, 100 k, 2 w	AB CLU1041	Ohmite
R58	Not used		
R59	Resistor, composition, 100 ohms ±5%, 1 w		Allen-Bradley
R60	Resistor, wire-wound, 2.5 k, 25 w	0208	Ohmite
R61	Resistor, wire-wound, 35 k, 10 w	1-3/4 D-54-F	Ohmite
R62	Resistor, wire-wound, 500 ohms, 50 w	0403	Ohmite
R63	Resistor, variable, 1 k, 50 w	J-1000-F2	Ohmite
R64	Resistor, composition, 10 ohms ±5%, 1 w		Allen-Bradley
R65	Resistor, composition, 10 k ±1%, 1/2 w	DCSH.	Dalohm

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
R66	Same as R4		
R67	Resistor, composition, 300 k ±5%, 1/2 w		Allen-Bradley
R68	Resistor, composition, 18 k ±5%, 1/2 w		Allen-Bradley
R69	Same as R4		
R70	Resistor, composition, 470 ohms ±5%, 1/2 w		Allen-Bradley
R71	Resistor, composition, 100 ohms ±1%, 1/2 w	DCSH-1/2	Dalohm
R72	Resistor, variable, 20 ohms, dual	19195	Clarostat
R73	Resistor, variable, 1 ohm, 10 w	1 3/4-D-57-D	Ohmite
R74	Resistor, composition, 1 k ±1%, 1/2 w	DCSH-1/2	Dalohm
R75	Same as R56		
R76	Same as R42		
R77	Resistor, composition, 18 ohms ±5%, 2 w		Allen-Bradley
R78	Same as R42		
R79	Resistor, composition, 1 meg ±20%, 1 w	BAKW	RPC
S1	Switch, dpst	7590-L	Cutler-Hammer
S2	Switch, pushbutton; Disconnect, Hi Volt; Disconnect, Lo Volt;	113270 3471-02-C22 113326	AIL AIL AIL
S3	Switch	PA2031	Centralab
T1	Transformer	R20A	Triad
T2	Transformer	PC8405	Stancor
T3	Transformer	A-20	UTC
T4	Transformer	CV5(02-20-015)	SOLA
V1	Tube, electron	6W6GT	RCA or equivalent

Reference Symbol	Name of Part and Description	Designation or Std. Type	Mfr.
V2	Tube, electron	6AU6	RCA or equivalent
V3	Tube, electron	0A2	RCA or equivalent
V4	Tube, electron	12AX7	RCA or equivalent
V5	Tube, electron	12AU7	RCA or equivalent
V6	Tube, electron	12AT7	RCA or equivalent
V7	Same as V6		
V8	Tube, electron	6AU5GT	RCA or equivalent
V9	Tube, electron	6AU4GTA	RCA or equivalent
V10	Tube, electron	6AS7GA	Tung-Sol or equivalent
V11	Same as V6		

TABLE IX

NOISE TUBE CURRENT AND REPLACEMENT DATA

AIL Type To Noise Generator	Frequency Range (kmc)	Noise Tube Current (ma)	Noise Tube AIL P/N
07010	0.2 - 2.6	175	112307
07048	2.6 - 3.95	200	112990
07049	3.95 - 5.85	200	113827
07050	5.85 - 8.20	200	113827
07051	7.05 - 10.0	175	112307
07052	8.2 - 12.4	175	112307
07091	12.0 - 18.0	175	112434
07053	18.0 - 26.5	175	112434

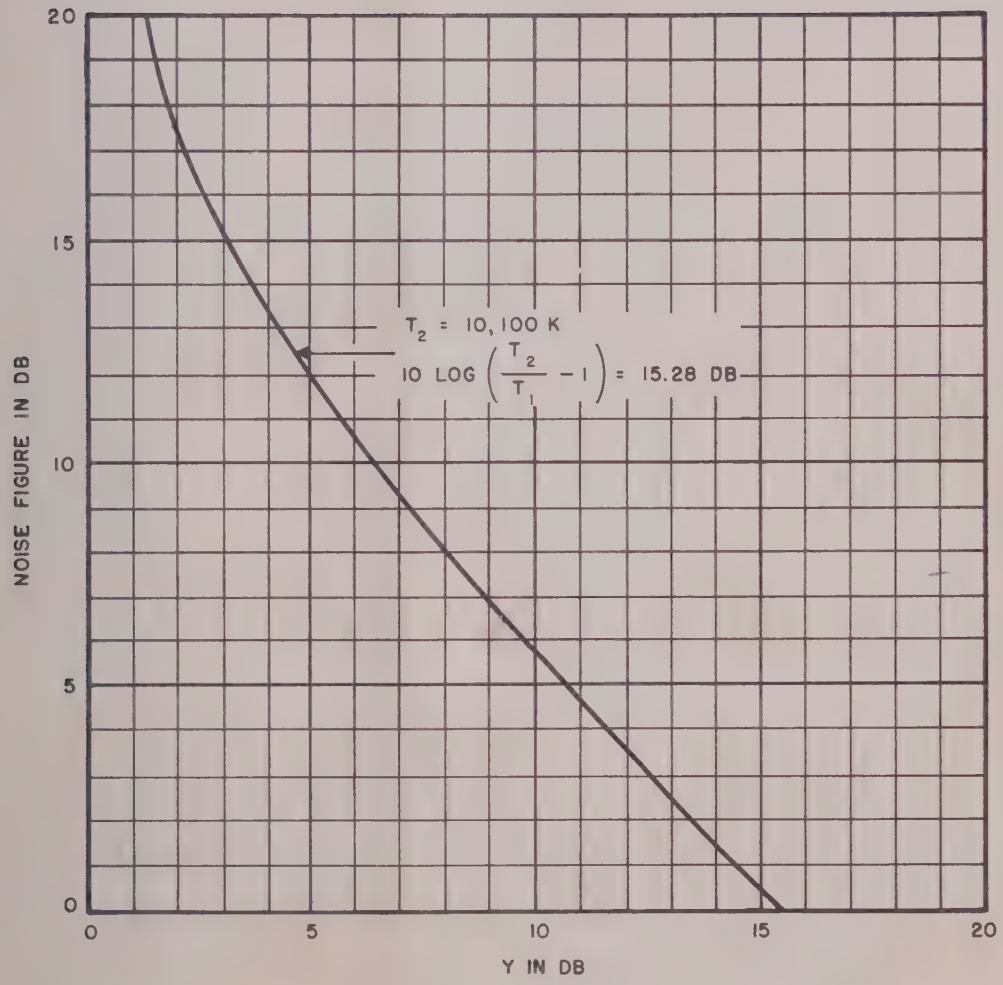


FIGURE 1. Y FACTOR VS NOISE FIGURE FOR 15.28-DB NOISE SOURCE

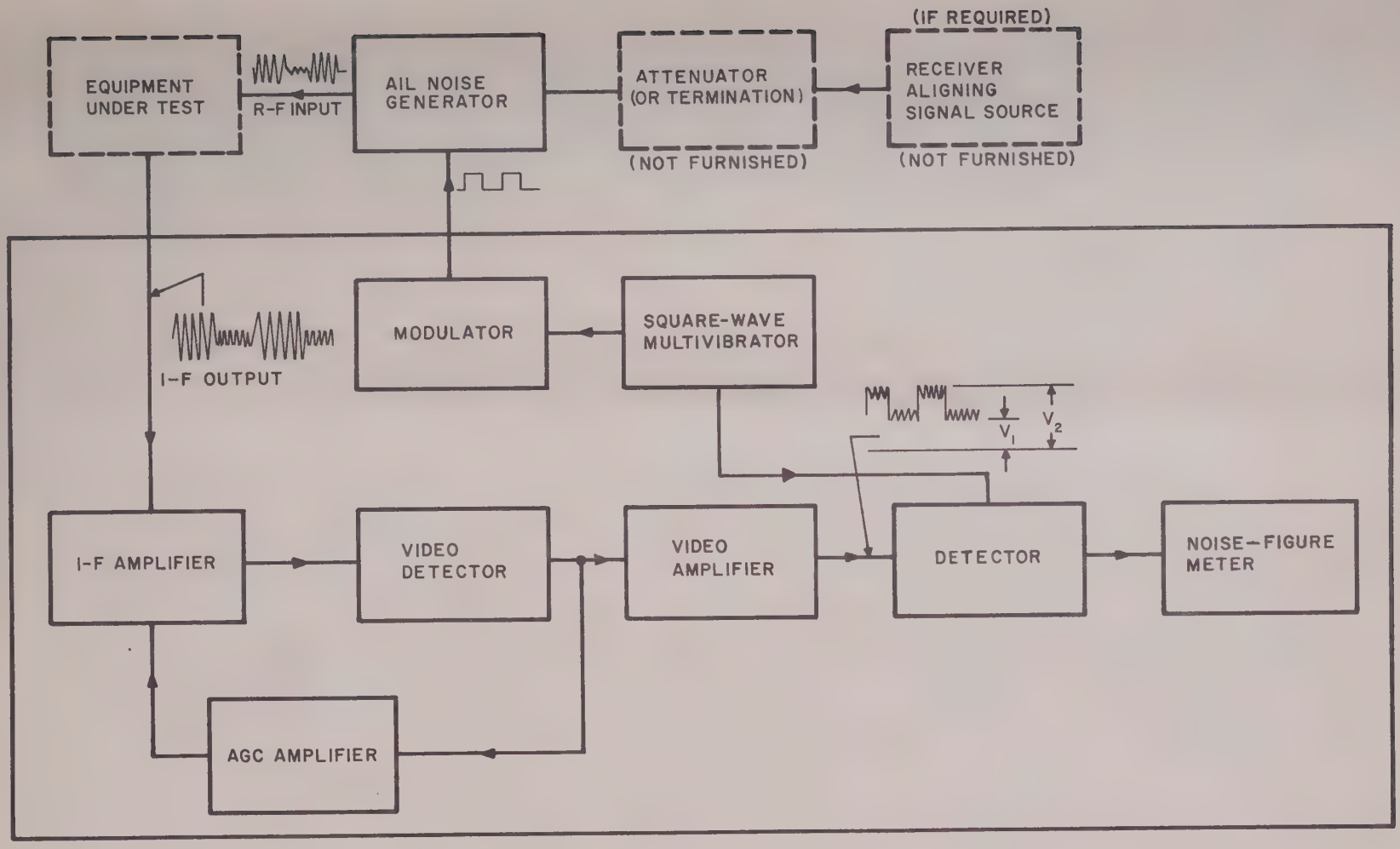


FIGURE 2. AUTOMATIC NOISE-FIGURE INDICATOR, FUNCTIONAL BLOCK DIAGRAM

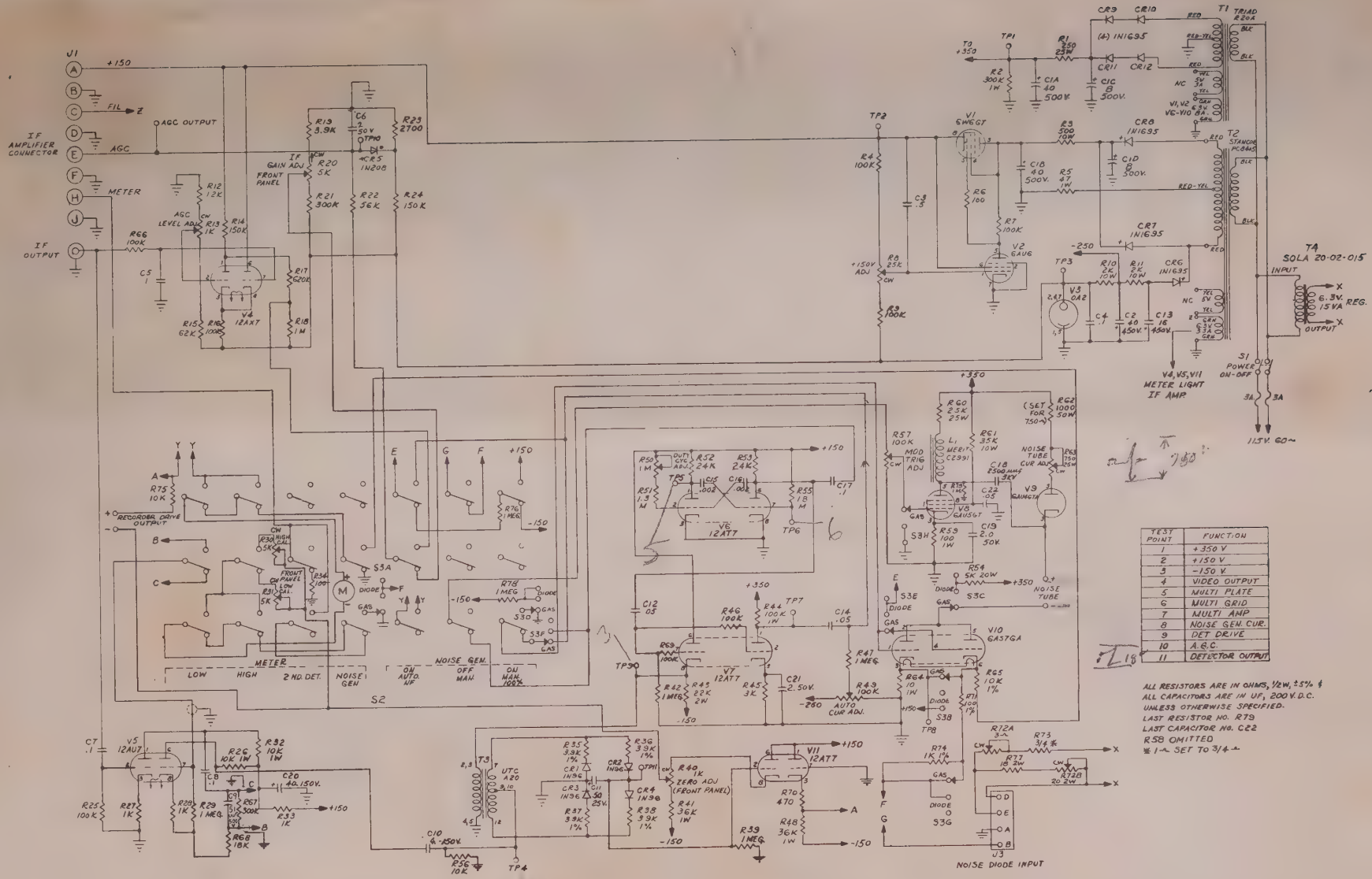
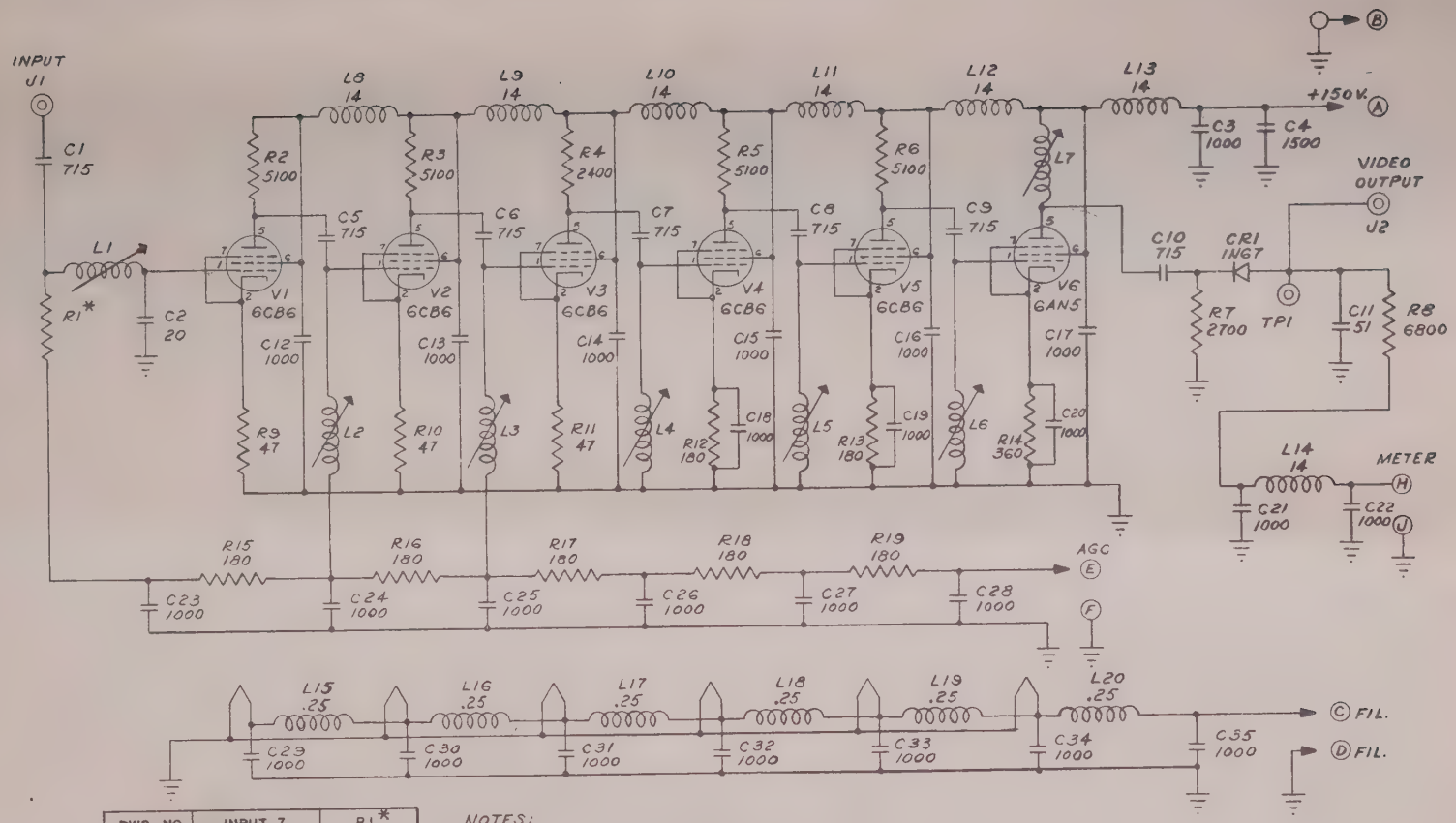


FIGURE 3. AUTOMATIC NOISE-FIGURE INDICATOR, SCHEMATIC DIAGRAM



DWG NO.	INPUT Z	R1*
113334-1	90 Ω	91 Ω
113334-1	50 Ω	51 Ω

COIL NO.	A.I.L. DWG. NO.	TUNING Mc
L1	112238	—
L2	112239	33.7
L3	112240	26
L4	113333	29
L5	112239	33.7
L6	113333	26
L7	112240	29

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/2W, ± 5% AND ALL CAPACITOR VALUES ARE IN UUF, ± 20% AND ALL COIL VALUES ARE IN UH UNLESS OTHERWISE SPECIFIED.

FIGURE 4. I-F AMPLIFIER OF AUTOMATIC NOISE-FIGURE INDICATOR, SCHEMATIC DIAGRAM

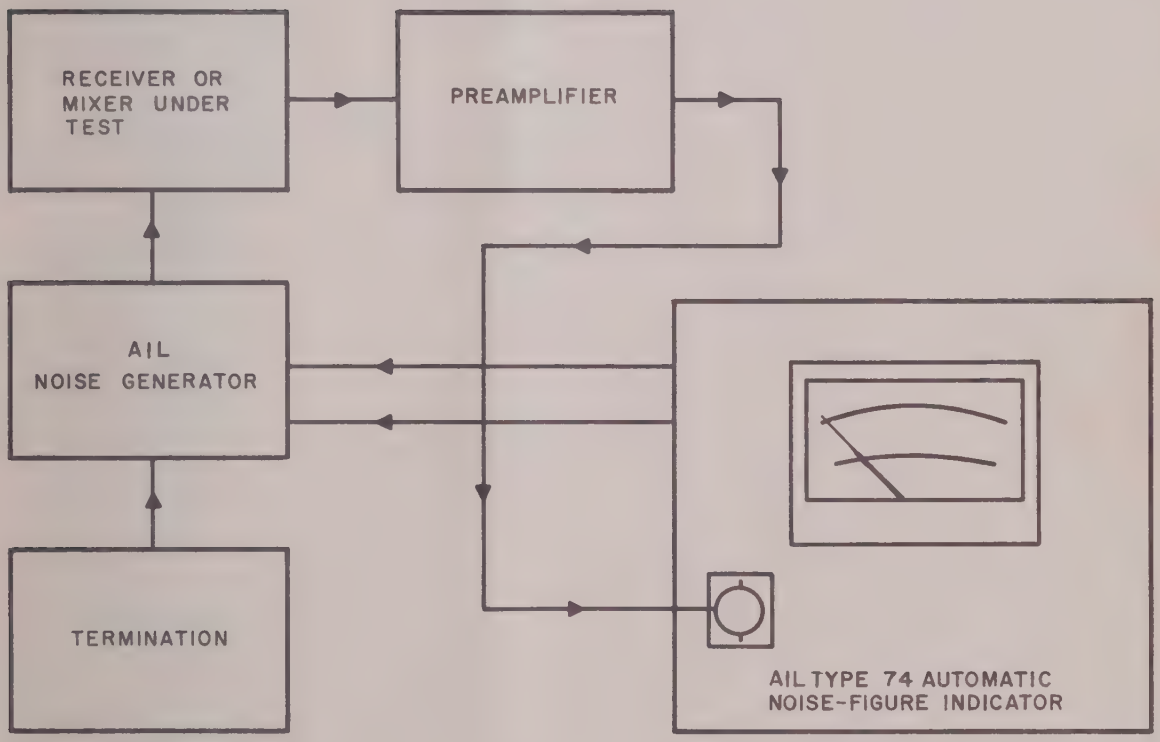


FIGURE 5. TYPICAL BENCH SETUP USING AUTOMATIC NOISE-FIGURE INDICATOR AND NOISE GENERATOR FOR AUTOMATIC NOISE-FIGURE MEASUREMENT

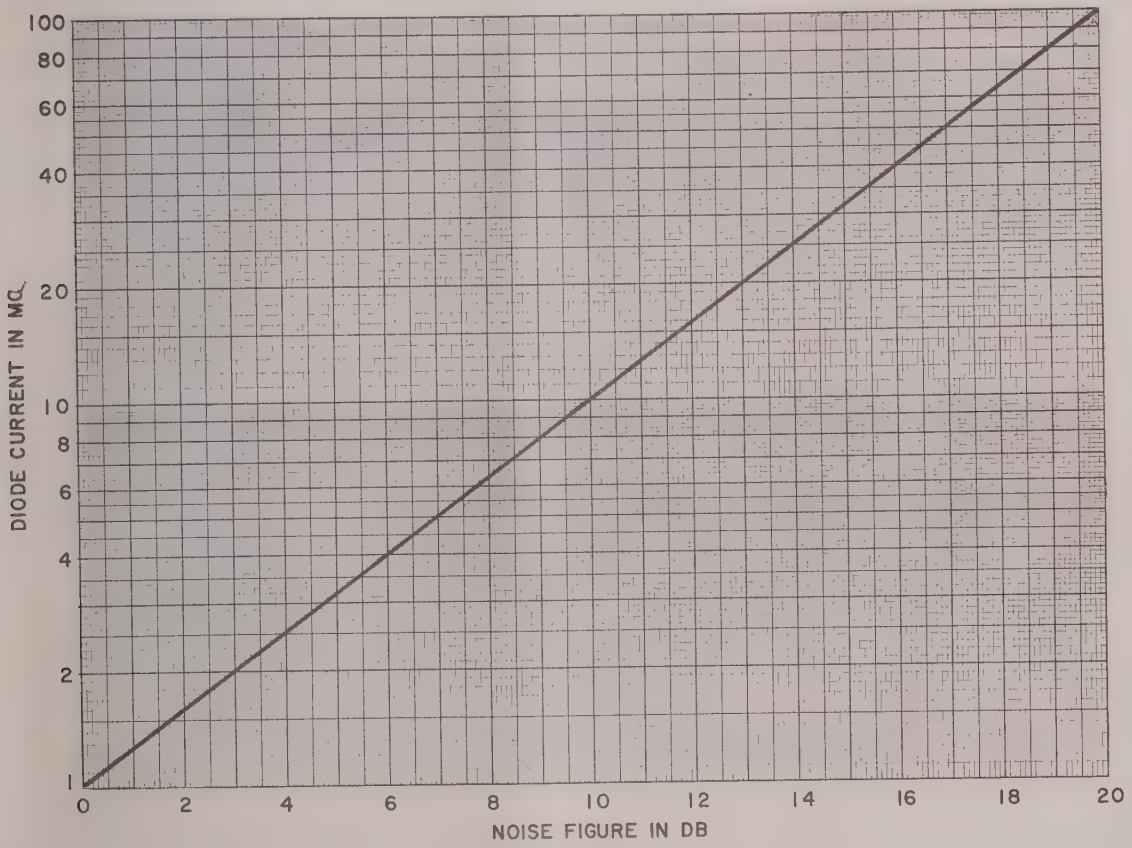
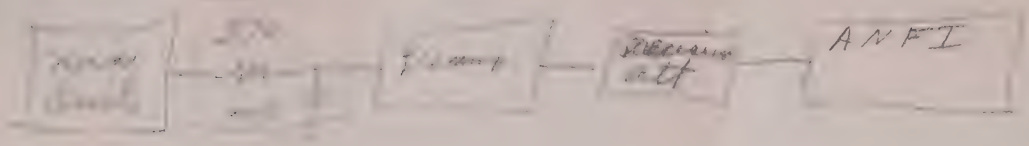


FIGURE 7. NOISE DIODE CURRENT VS NOISE FIGURE

Set up to check noise of Pre-amps 30 mc Noise Figure
Follow Procedure on P. 13 Sec 431 1.80 dB



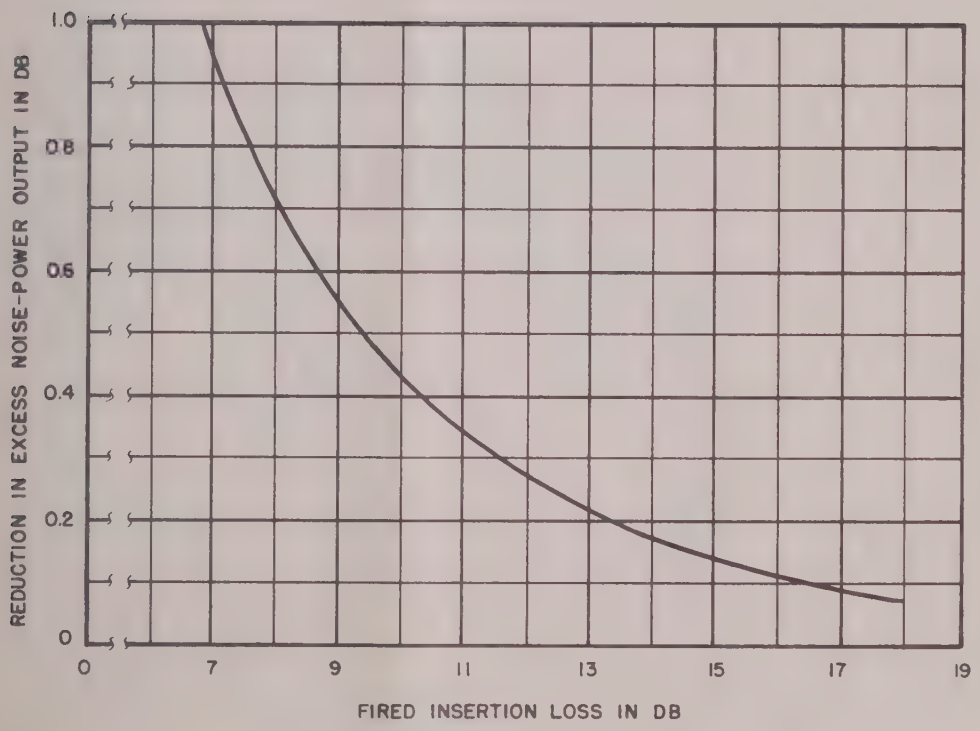
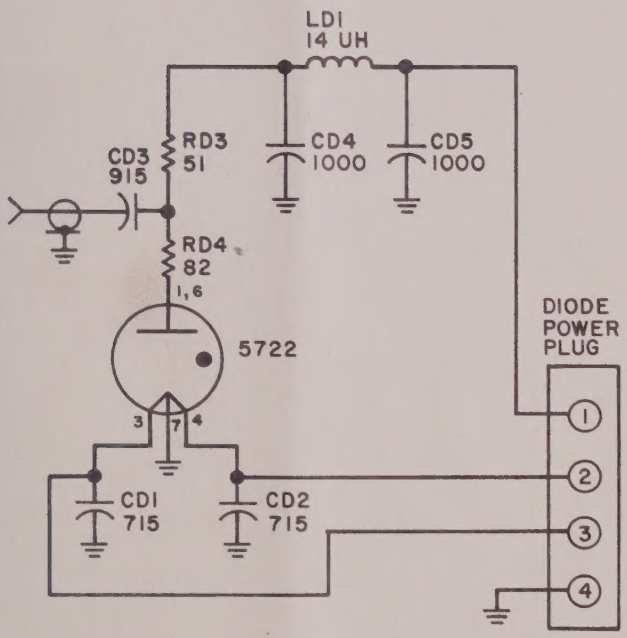


FIGURE 8. REDUCTION IN EXCESS NOISE-POWER OUTPUT AS A FUNCTION OF FIRED INSERTION LOSS



UNLESS OTHERWISE NOTED:

RESISTOR VALUES ARE GIVEN IN OHMS ±5%, 1/2 WATT
CAPACITOR VALUES ARE GIVEN IN UUF

FIGURE 9. NOISE DIODE, SCHEMATIC DIAGRAM

H.V. Connector on A.I.L. Noise generator.
(connector to HV side of noise tube on waveguide)

Gartar spring	part # 113974	cost .50
Anode sleeve	116840	6.50
Anode contact sub assembly	116837	7.50

92596